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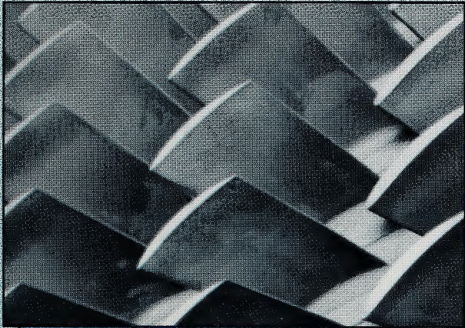
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SCIENCE 7

STUDENT SUPPORT GUIDE




MODULE 2: STRUCTURES AND DESIGN



**Distance
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ACKNOWLEDGEMENTS

This module has been based on **Science Directions 7** by John Wiley & Sons/Arnold Publishing Ltd., 1989. Program consultant was Douglas A. Roberts. The author team for the complete text included Wilson C. Durward, Eric S. Grace, Gene Krupa, Mary Krupa, Alan J. Hirsch, David A.E. Spalding, Bradley J. Baker, and Sandy M. Wohl. Contributing author was Jean Bullard. Portions of **Science Directions 7** have been used throughout and have been adapted in a variety of ways.

Cover photographs of Menzies LRT Bridge (1989), over North Saskatchewan River, Edmonton, Alberta, courtesy of Dave Mussell, Edmonton.

Note to the Parent or Guardian

This Science Student Support Guide contains answers to activities in the accompanying Module Booklet. It should be kept secure by the parent or guardian if the student is under 16 years of age. Younger students should not have access to this Guide except under supervision.

This Student Support Guide does not contain the answers to the accompanying Assignment Booklet. The Assignment Booklet will be graded by the student's distance education teacher.

Science 7
Student Support Guide
Module 2
Structures and Design
Alberta Distance Learning Centre
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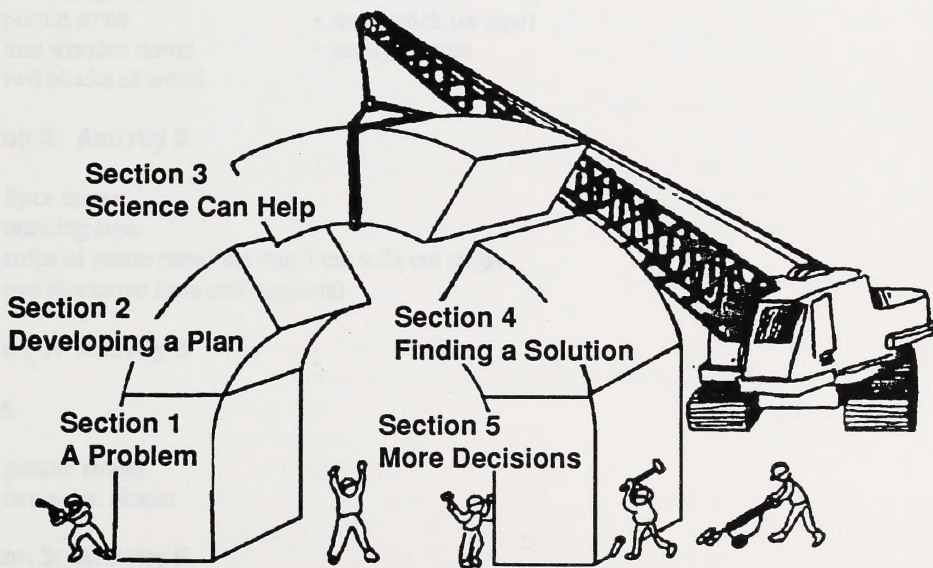
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Module 2 - Structures and Design: Overview

The major emphasis of this module is on science and technology. However, opportunities are also present to support learning regarding the nature of science and the relationship among science, technology, and society.

In Module 2, students will look at structures and at how they are put together. They will compare structures made by people with structures in the natural world. While examining structures and their design, students will also consider the function of the overall structure, as well as the function of individual components.

Module 2 will give students the opportunity to plan and build some structures on their own. They will discover how to choose the best materials for making the structures and why one design is stronger than another. By doing the activities in this module, students will develop the skills of technological problem solving. They will come to appreciate that often there is more than one solution to a problem and that there is value in considering alternative approaches. Social, environmental, and aesthetic considerations are also taken into account in this module.



Evaluation

The student's successful completion of all assignments will depend on practice obtained while doing the various activities. Many choices of activities have been provided so that students have some control over their own learning.

The following distribution of marks will determine the student's grading for this module.

ASSIGNMENT	VALUE
Section 1	17 Marks
Section 2	14 Marks
Section 3	22 Marks
Section 4	21 Marks
Section 5	26 Marks
TOTAL	100 Marks

Each module in Science 7 is worth 10% of the student's course mark. The final test, based on the learnings from all six modules, is worth 40% of the total final grading.

Materials Needed for Module 2

Comment:

For a complete overview of the materials needed for Module 2 and how the topics are developed, it may be helpful to preview the contents of Module 2. In some cases if the materials suggested are not readily available, the learning facilitator may be able to substitute suitable materials for the student, so that the activities can be completed successfully.

The materials needed for Module 2 and the activities in which they are to be used are as follows:

Section 1: Activity 1

- nine index cards (3 blue, 3 yellow, and 3 red)
- a block labelled *model boat*, or a toy boat
- two other blocks of wood (These are to represent the banks of the river.)
- eight test bags (Each bag contains 100 g of sand or other suitable substance.)

Section 3: Activity 1

- dried spaghetti
- plastic straw
- thin wooden dowel
- two blocks of wood
- force meter
- metre stick (or tape)
- safety glasses

Section 3: Activity 2

- force meter
- masking tape
- strips of poster paper cut into 7 cm × 21 cm strips
- two blocks (to form end supports)

Section 3: Activity 3

Part A

- pleated straws
- two wood blocks

Section 3: Activity 5

- two wooden coffee stir sticks, or strips of stiff cardboard, with holes near ends
- a brass paper fastener
- two wood blocks
- a length of string (about 30 cm)
- tape

Section 3: Activity 6

- nine wooden coffee stir sticks with holes near the ends
- six brass paper fasteners
- a wood dowel (20 cm or longer)
- two wood blocks

Section 3: Extra Help

- 30 cm lengths of four different types of thread
- wooden block 30 cm or longer
- bag or plastic container to hold the load
- 100 g bags of sand

Section 4: Activity 1

- | | | |
|-------------|--------------------|----------|
| • pins | • straws | • thread |
| • spaghetti | • thin wood dowels | • glue |

Section 4: Extra Help 1

- strips of stiff cardboard
- paper fasteners or pins

Section 4: Extra Help 2

- two sheets of paper or thin cardboard (about 28 cm × 22 cm)
- eight 100 g bags of sand
- two wooden blocks

Section 5: Activity 1

- | | |
|---------------------------------|--|
| • two drinking straws | • five metal paper clips |
| • two small containers (250 mL) | • a cardboard tube |
| • a marble | • a sheet of stiff cardboard (20 cm × 20 cm) |
| • scissors | • two large rubber bands |
| • a ruler | • modelling clay |
| • adhesive tape | • water |
| • sand | |

Media (Optional)

The following two video programs are suggested if the students are to use the optional media learning pathways in Module 2.

Section 3: Activity 3

Part B

Science of Architecture: Part 2 Push or Pull (30 minutes)

Section 5: Activity 2

Part B

Science of Architecture: Part 1 Loads – Dead or Alive (first 10 minutes)

Note: Videocassettes used in this course may be available from the Alberta Distance Learning Centre, or call your local school authorities.

The remainder of this Student Support Guide for Module 2 contains the answers and guidance to assist you in correcting the student's work in the Activities. So that the learning facilitator (parent/guardian) does not have to keep referring to the Student Module Booklet, the questions are reprinted from the Student Module Booklet, and the suggested answers are printed in italics. Comments where applicable are made to guide the learning facilitator.

Correct and discuss the answers with the student as the student completes each activity. In this way the student receives immediate feedback to clarify and reinforce basic understanding before moving onto the next Activity.

Towards the end of each section there are Follow-up Activities. Here the activities are separated into two strands: Extra Help and Enrichment. If students had some difficulties understanding the concepts and the activities within the sections, it is recommended that they do the Extra Help. If students had a clear understanding of the concepts and had few difficulties completing the section activities, it is recommended that they do the Enrichment. As the learning facilitator, you should assist the student in choosing the appropriate path in the Follow-up Activities.

The assignments in the Assignment Booklet are to be done under the supervision of a learning facilitator. Ensure that the student always supplies his or her own written responses in the Assignment Booklet. Because these are not tests, the students can refer to the Module Booklet and any additional notes that have been made. Assignments are always marked by a teacher. Wait until all the assignments are completed before submitting the Assignment Booklet.

Section 1: A Problem

By the end of this section students should be able to

- demonstrate a systematic way to solve practical problems
- describe the type of problems that technology can solve
- describe why creativity and inventiveness are useful in solving problems

Section 1: Activity 1

Comments:

- In this activity students are to solve a problem. They are to build a prototype of a bridge that will meet the specifications as stated in the Module Booklet. Check to see that the student has understood the problem, has kept notes of what was done during construction, and has built the prototype to meet the specifications listed.
 - The three colours of index cards is to allow the student to explore several trials, if desired. Only three index cards are required for the actual construction of the bridge. If index cards are unavailable, thin cardboard sheets may be used instead.
 - Books can be substituted for blocks of wood to form the banks of the river.
 - The eight 100 g test bags should be made and saved for use in later activities. If sand is not available, rice, salt, sugar, grain, etc. can be used instead. A kitchen scale, spring scale, or balance scale can be used to measure out 100 g of sand or other substance for each test bag. Small freezer bags or sandwich bags could be used to contain the sand.
1. Once you understand the problem, you should consider several alternatives. What approaches to the problem can you think of? Make some rough sketches in the following space.

Answers will vary. Students should show one or more rough drawings that represent their first ideas.

2. How did you finally decide which design to take to the testing stage?

- Some alternatives are not practical because of factors such as cost, time involved, and materials needed.
- If you are considering several alternatives, review the specifications to see if one alternative is better than the others.

Answers will vary. Students will describe in their own words what they think to be important in selecting a design. The additional points under the question may provide some guidance to students. Answers should show evidence of critical thought and might deal with one or more of the following considerations:

- *availability of materials*
- *extent to which designs meet specifications*
- *ease of construction*
- *similarity to designs observed elsewhere*

3. Where did you get your ideas?

- Has someone already solved this problem or a similar problem? How did they do it?
- Can you think of a new, creative solution?
- Can you put several ideas together in a new way?

Answers will vary. Students should be encouraged to use a variety of sources for their ideas (e.g., books and other print materials, television, designs of actual bridges).

4. Did you make improvements, even after you tested your bridge, to make sure it was big enough and strong enough? What changes did you make? Describe or draw the changes.

- Making adjustments while building a prototype is called *troubleshooting*. This allows you to deal with any minor difficulties that you did not anticipate.

Answers will vary. Students should note changes they made to improve their designs.

5. How did you decide you were finished?

- Compare your prototype with the purpose and the specifications of the problem.
- At some point you decided you were satisfied with your solution. What helped you make this decision?

Answers will vary. Answers should indicate that the bridge was built according to design or that the student had tried a new idea that appeared worth testing.

6. Were you satisfied to meet the minimum requirements, or did you try to make the strongest structure possible?

Answers will vary. It is satisfactory to work toward the basic requirements or to go beyond the requirements.

7. Draw a detailed diagram of your prototype. Record how it behaved in the test conditions.

Answers will vary. Drawings and descriptions should show plausible methods of design.

Note: The student should now complete the assignment for Section 1 in the Module 2 Assignment Booklet.

Section 2: Developing a Plan

By the end of Section 2 students should be able to

- compare design in the natural world and in the manufactured world
- describe a strategy for approaching a technological problem
- describe the design of a structure
- infer the function of a structure

Section 2: Activity 1

1. Examine the photographs of natural and manufactured objects on pages 78 and 79 of *Science Directions 7*. Then complete the following table using the instructions that are given. Note that an example has been done for you.
 - a. In the first column, list all the natural structures in the photographs.
 - b. Match up each natural structure with a manufactured structure that has a similar design. List the matching manufactured structures in the second column.

- c. In the third column, describe what part or parts each pair of structures have in common.

Natural Structure	Manufactured Structure (made by people)	Design in Common
plant seed with extended fine hairs	parachute	both have parts that are designed to catch the wind
<i>elbow</i>	<i>hinge</i>	<i>both involve movement between joined sections</i>
<i>spider web</i>	<i>net</i>	<i>both are used to catch prey while moving by</i>
<i>mushroom</i>	<i>umbrella</i>	<i>both shed water to the side</i>
<i>flower</i>	<i>satellite receiver dish</i>	<i>both are open structures that are curved upward at the edges</i>
<i>tree</i>	<i>clothes tree</i>	<i>both have main stems and branches</i>

2. What is meant by the term *manufactured*?

Something made by people or not found in the natural world is manufactured.

3. a. Do you think that the designer of these manufactured structures copied natural structures?

Yes or no are both acceptable.

- b. Explain why or why not.

If yes, the explanation should focus attention on the strong similarities.

If no, the explanation should focus on differences.

Look for evidence of critical thought in the student's answer.

Section 2: Activity 2

1. Turn to page 80 of *Science Directions 7*. Do numbers 1, 2, and 3 as outlined under Activity 2-2. After cutting out the tangram pieces, see if you can reassemble all your seven pieces of paper to make a duck, a sailboat, a kangaroo, and a watering can as shown.

Check to see that the student had worked with the tangram pieces and practised making different designs such as a duck, sailboat, kangaroo, and watering can that were illustrated in the textbook.

2. Design two structures of your own; one that represents a manufactured object and one that is something from nature. Draw the outline of each structure in the following space.

Manufactured Structure	Natural Structure
<i>Answers will vary. The overall approach should be similar to what was shown in the previous examples.</i>	

Section 2: Activity 3

1. The first column of the following chart lists common functions of manufactured structures. Complete the chart by writing the name of two manufactured structures for each function. The first one has been completed for you.

Answers will vary. The following answers are examples.

Function	Structure 1	Structure 2
communicating	pen	telephone
supporting	<i>chair</i>	<i>bookcase</i>
containing	<i>cup</i>	<i>box</i>
lifting	<i>crank</i>	<i>elevator</i>
fastening	<i>belt</i>	<i>staple</i>
sheltering	<i>house</i>	<i>tent</i>
transporting	<i>truck</i>	<i>wagon</i>
separating	<i>sieve</i>	<i>egg separator</i>
breaking	<i>axe</i>	<i>nutcracker</i>

Section 2: Follow-up Activities

Extra Help

1. a. Choose three structures that you can examine. You could choose a desk, a skateboard, or a framed picture, but do not choose something too complex. State the names of these structures in the first column in the following chart.
- b. Complete the other columns in the chart for each structure.

Structure	Part (s)	Shape	Quantity
<i>Answers will vary. Students are to give three answers. The following answer is an example.</i>			
Skateboard	wheels	circle	4
	axles	cylinder	2
	board	oval	1

2. Which shapes were most common?

Answers will vary, but they should be consistent with the examples given in the previous chart.

3. Which shapes were least common?

Answers will vary.

4. Name any of the major parts that could be further divided into smaller parts.

Answers will vary.

5. Describe how you could change the design of one of the structures so that it could still be used for the same purpose, but for a user that has special needs.

Answers will vary. Students should show evidence of critical thought.

Enrichment

Note: Students are to do either Part A or Part B.

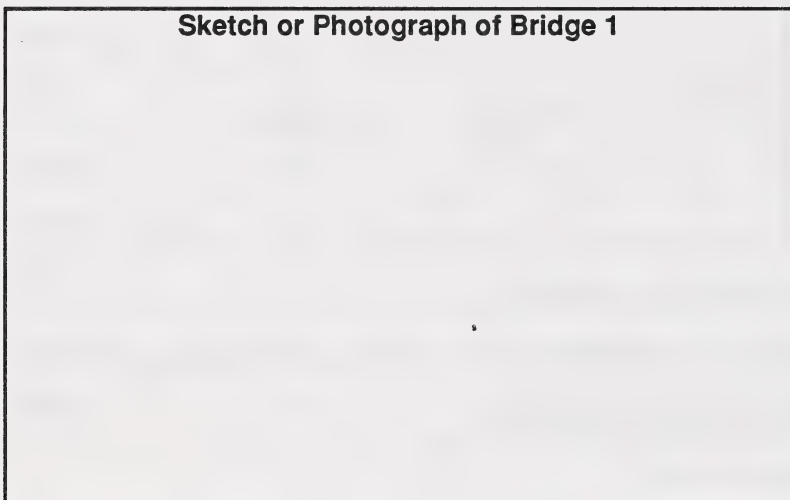
Part A: Field Trip and Part B: Research

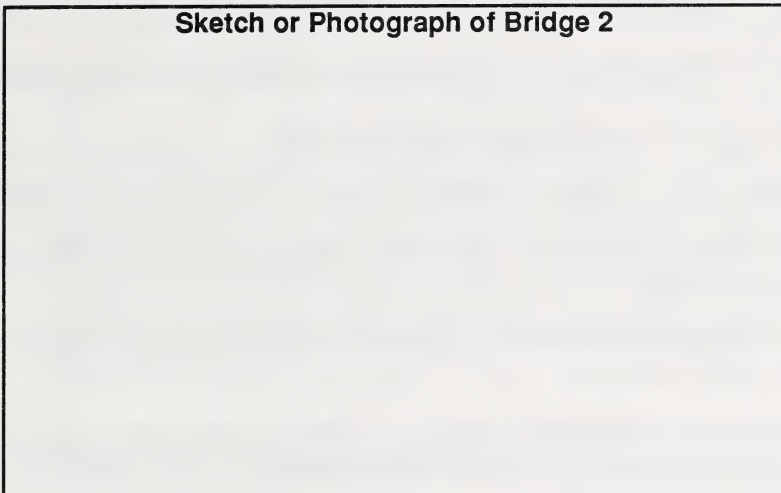
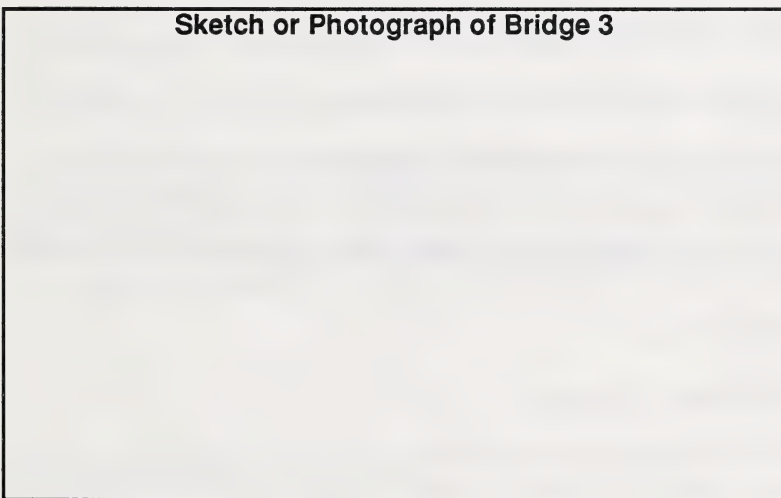
Note: Students are to visit the site of three local bridges (Part A). If this is not possible, they are to look through magazines or books to find examples (Part B).

Students should attach snapshots or sketches of the actual bridges (Part A) or photographs or sketches from books or magazines (Part B). Illustration of different kinds of bridges should be encouraged.

1. Sketch the bridges or take snapshots of them.

Sketch or Photograph of Bridge 1



Sketch or Photograph of Bridge 2**Sketch or Photograph of Bridge 3**

2. Describe the function of each bridge. (How is the bridge used? Why is it needed?)

Bridge 1

Bridge 2

Bridge 3

Answers will vary. For example, a bridge might serve as an overpass that carries one lane of traffic over another.

3. What differences did you notice in the design of these three bridges?

Answers will vary. Answers should show evidence of critical thought and careful observation.

4. What was similar about the design of the three bridges?

Answers will vary. Students should show evidence of critical thought and careful observation.

5. Describe one way in which you might be able to improve your prototype bridge after looking at these three bridges.

Answers will vary. Students should indicate some aspect or feature of the designs that might be useful in their own bridge.

Note: The student should now complete the assignment for Section 2 in the Module 2 Assignment Booklet.

Section 3: Science Can Help

By the end of this section students should be able to

- demonstrate how to test the strength of material
- demonstrate how to test the strength of different shapes of structures
- describe all forces as compression, tension, or a combination of compression and tension
- explain the advantages and disadvantages of structural design based on scientific information
- describe how scientific knowledge can help solve technological problems

Section 3: Activity 1

Testing the Strength of Materials

You will now investigate the relationship between the type of material and its strength. You will compare the strength of beams made of spaghetti, wood, and plastic. Although the answer may seem obvious, by using this scientific investigation you will have observations to support your conclusions.

Caution

Wear your safety glasses during this experiment. Even a small piece of dried spaghetti could cause injury to your eyes.

Steps to Follow

Step 1: To create a beam, suspend the material you are testing between two blocks which are 20 cm apart.

Step 2: Use the force meter to pull down on the centre of the beam with a force of 0.5 N.

Step 3: Observe how much the beam bends. The amount of bending is called the **deflection**. Observe and record the amount of deflection. The following diagram will help show you what to look for and what to measure. To measure the deflection, it is helpful to have a ruler and another straight edge. Lay the straight edge across the supports by the beam. The spread between the straight edge and the lowest point of the beam is the deflection. Use a ruler to measure this distance in centimetres.

Step 4: Repeat steps 2 and 3, increasing the downward force by 0.5 N for each test, until the beam breaks. Observe and record your measurements.

Comments:

- If a force meter is unavailable students can use a small light container and add masses such as marbles or sugar cubes to the container until the beam breaks.
- The wooden dowel should be approximately 2 mm or 3 mm in thickness.
- If wooden dowels are unavailable then suitable substitutes may include plant supports, skewer sticks, or thin twigs.
- The charts may be extended to accommodate extra observations, if necessary.

Spaghetti Test

1. Use one strand of spaghetti as your beam. Follow steps 1-4 to test the strength of a spaghetti beam. Complete the following chart.

Observation Chart for Spaghetti

Force (N)	Deflection (cm)
0.5	
1.0	
1.5	
2.0	<i>Answers will vary. Normally the deflection will increase by even intervals as similar units of force are added.</i>
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	

2. What was the maximum deflection just before the beam broke?

Answers will vary. Check the answer with the chart.

3. What force was required to cause the beam to break?

Answers will vary. Check results with those in the chart.

Wood Dowel Test

4. Repeat the experiment using a wood dowel as your beam. Complete the following chart.

Observation Chart for Wood Dowel

Force (N)	Deflection (cm)
0.5	
1.0	
1.5	
2.0	<i>Answers will vary. The deflections will be much smaller than that of the spaghetti.</i>
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	

5. What was the maximum deflection just before the beam broke?

Answers will vary. Check with the information in the chart.

6. What force was required to cause the beam to break?

Answers will vary. Check with the information in the chart.

Plastic Straw Test

7. Repeat the experiment using the plastic straw as your beam. The plastic straw will not break like the spaghetti and the wood dowel did. When the straw bends and no longer supports the increased downward force, consider it to be broken. Complete the following chart.

Observation Chart for Plastic Straw

Force (N)	Deflection (cm)
0.5	
1.0	
1.5	
2.0	<i>Answers will vary. Deflection will be intermediate between those found for the spaghetti and those found for the wood dowel.</i>
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	

8. What was the maximum deflection just before the beam broke?

Answers will vary. Check with the information in the chart.

9. What force was required to cause the beam to break?

Answers will vary. Check with the information in the chart.

Interpretations

10. Rank the materials in order of which required the most force to break, to which required the least force to break.

Wood Dowel
(strongest)

Plastic Straw

Spaghetti
(weakest)

11. a. Did using a force meter help you determine how much stronger one material was than the others?

Yes

- b. Explain.

The force meter provided a means of comparing the effects of the same force on different material, or for the same amount of force, some materials bent more than others.

Section 3: Activity 2

Testing the Strength of Shapes

In this activity you will investigate the relationship between the shape of a material and its strength when used as a beam.

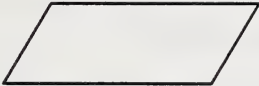
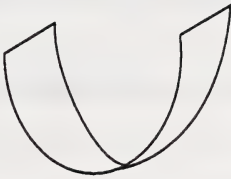
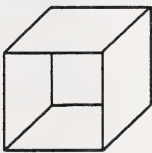
There are many shapes you can make using poster paper. You can fold, bend, and tape the poster paper. Whatever shape you choose, the beams you make from the poster paper must span a gap of 18 cm. Use the wood blocks to form supports at each end of the beam.

Follow the instructions and answer the questions.

Comments:

Some of the following questions required the student to perform certain observations, or constructions, while the student followed the instructions to complete questions 1 to 12.

1. Look at the following three examples of shapes that can be made out of a 7 cm × 21 cm strip of poster paper.

Flat	U-Shape	Box Shape
		

2. Sketch two other possibilities. Remember, the beam must be made out of one strip of poster paper. Also, the beam must span an 18 cm gap.

Your A Design	Your B Design
<i>Sketches of designs will vary.</i>	

3. Which of the five shapes do you think will make the strongest beam?

Answers will vary.

4. Make the five shapes, using one strip of cardboard for each shape. Fold, bend, and tape the cardboard, if necessary, to retain the desired design.
5. Place the two wood blocks 18 cm apart. Set the flat beam on the supports to span the gap.
6. Use tape to attach the force meter onto the middle of the beam.
7. Gently apply downward force onto the beam.
8. Record the force required to cause a deflection of 1 cm. (If the shape permanently distorts before a deflection of 1 cm, record the force used just before the beam broke.)
9. Repeat the preceding steps using the other beams.
10. Record your measurements in the observation chart.

Observation Chart for Strength of Different Beam Shapes

Shape of Beam	Force (N) (required for deflection of 1 cm)
Flat	
U-Shape	<i>Answers will vary.</i>
Box Shape	
Your A Design	
Your B Design	

Interpretations

11. Which shape was able to withstand the greatest bending force?

Answers will vary. Of the shapes given, the box shape will usually be strongest.

12. How could this kind of scientific knowledge help you build a better prototype bridge than the one you built in Section 1?

Box beams could be used in that structure, or students may give another acceptable answer based on their observations.

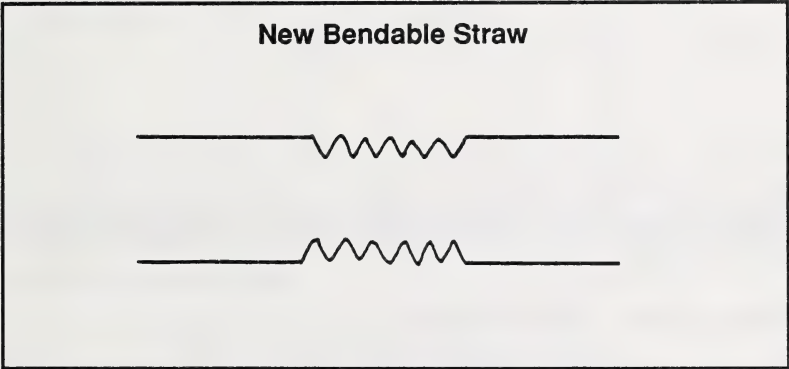
Section 3: Activity 3

Note: Students are to do either Part A or Part B.

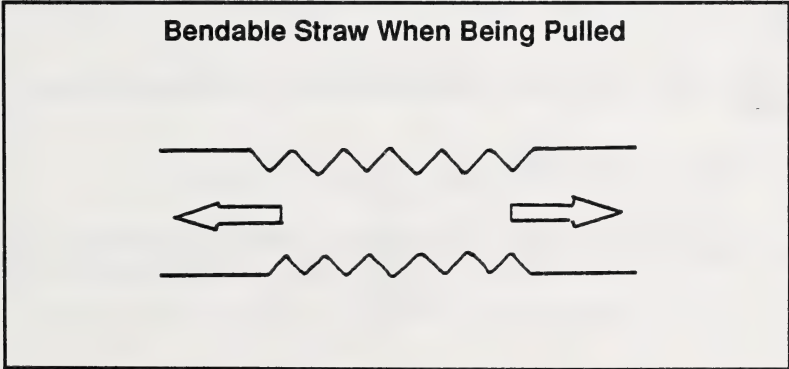
Part A: Using Pleated Straws

Follow the instructions and answer the questions.

- 1. Observe a new bendable straw. Sketch the appearance of the pleated section.



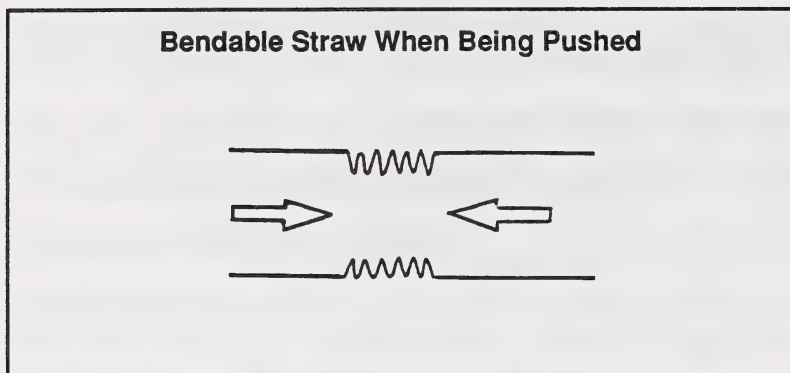
- 2. While holding the straw by its ends, gently pull on the ends. Sketch how the appearance of the pleated section changes when you are pulling. (The change will be very slight, so look closely)



- 3. Pulling is a type of force. Another name for this kind of force is **tension**. By pulling on the ends of the straw you cause tension in the straw. What happens to the pleated section during tension?

It is stretched out. (It lengthens.)

4. While holding the straw by its ends, gently push the ends of the straw toward the centre. Sketch how the appearance of the pleated section changes when you are pushing.



5. Pushing is a type of force. The scientific name for a pushing force is **compression**. By pushing on the ends of the straw you exerted a compressive force. What happened to the pleated section during compression?

It is squeezed together. (It becomes shorter.)

6. Using the words *push* and *pull*, describe the difference between a compression and a tension.

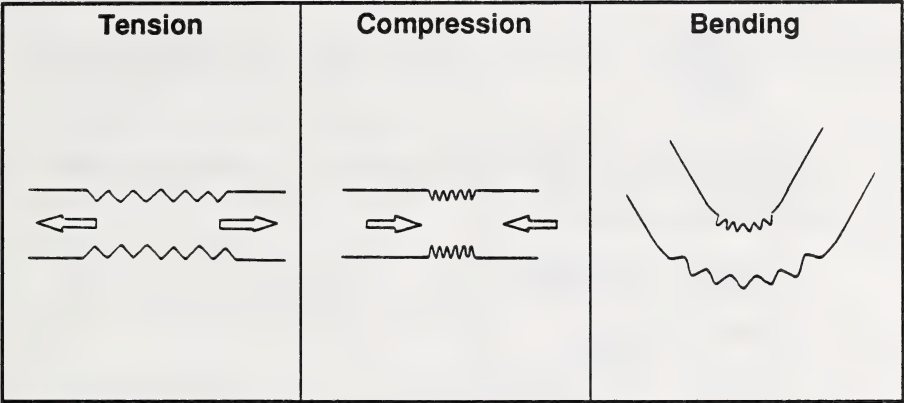
Compression is a pushing force. Tension is a pulling force.

7. Using words such as *squeeze* and *stretch*, describe what happens as a result of compression and tension?

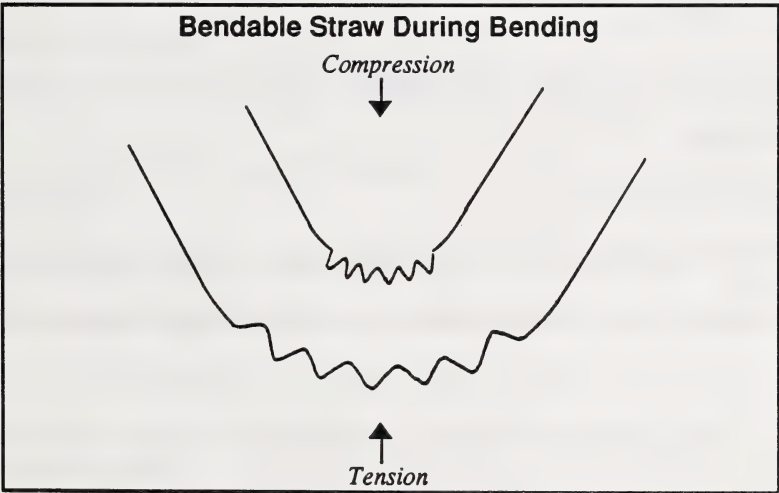
Compression causes something to be squeezed together; tension causes something to be stretched.

8. Use a new pleated straw to make a beam across two wood blocks.
9. Push down with your finger near the pleated section. Observe the appearance of the pleats. Look carefully at the top and the bottom of the pleated section. You have applied a bending force.

10. In the following spaces, draw what the pleats looked like during tension and compression. Then draw what the pleats looked like during bending.



11. Bending involves **both** compression and tension. The following diagram shows the pleated section of a straw during bending. Clearly indicate on the diagram where there is tension and where there is compression.



Interpretations

12. You have learned about three different types of forces.

- pulling
- pushing
- bending

These three forces can be thought of as examples of compression and tension. Show your understanding of this idea by writing *compression*, *tension*, or *both compression and tension* in the blank spaces that follow.

- pushing *compression*
- pulling *tension*
- bending *both compression and tension*

Part B: Videocassette

View the videocassette called *Science of Architecture, Program 2: Push and Pull* (30 minutes).

1. Define compression.

Compression is a pushing force (or a change in material that results from a pushing force).

2. Define tension.

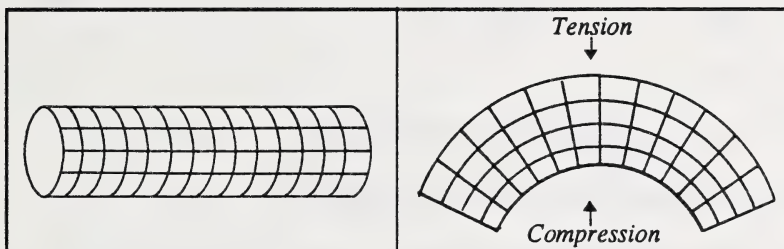
Tension is a pulling force.

3. Describe how bending can be explained as a combination of compression and tension.

When something bends, one side is under tension; the opposite side is under compression.

- During the videocassette the narrator uses a flexible rod to demonstrate how bending can be explained as a combination of compression and tension. He drew square patterns which changed shape during bending.

The following diagrams show a beam with squares drawn on it. Label the areas which are under compression and the areas which are under tension.



- Use the words, *push*, *pull*, *squeeze*, and *stretch*, to explain the diagram. If it helps, label parts of the diagram and refer to them in your explanation.

When something is bent, part of it is squeezed together. This part is said to be compressed. The opposite side is being pulled apart. This part is under tension.

Section 3: Activity 4

Read page 108 of *Science Directions 7* and study diagrams (a) and (b) near the top of the page.

- Can a greater load be supported by the beam shown in diagram (a) or by the beam shown in diagram (b)?

A greater load can be supported by beam (b).

- Give a reason to support your answer for question 1.

The load is being supported by a greater thickness of wood.

- Measure the distances AB, CD, and EF on the diagram of the beam when it is straight. Record the measurements.

- AB 8.7 cm
- CD 8.7 cm
- EF 8.7 cm

4. Now measure these same parts when the beam is bent under a load. To do this, lay a piece of string along the lines AB, CD, and EF on the beam as shown when it is bent under the load. Mark the ends of the lines on the string. Measure the string to find the lengths of the lines. Record the measurements.

• AB 7.5 cm

Line AB is shorter than EF, while line CD is longer than EF.

• CD 9.8 cm

• EF 8.5 cm

5. When the beam is bent, which line is under tension? CD

6. When the beam is bent, which line is under compression? AB

7. Is there a line in the curved beam that is neither under compression nor tension? How do you know?

Line EF is not under compression or tension.

If you measure this line it does not change when the weight is added.

8. What are some advantages of I-beams, L-beams, and Box-beams over solid beams.

They have less mass than solid beams. As a result they are less expensive. Also, with less mass of their own to support, they can support a greater load.

Section 3: Activity 5

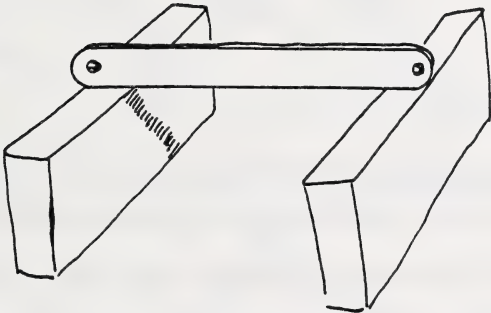
Now you will make a simple prototype building, using the wood blocks to form the supporting walls. You will use wooden stir sticks to make the roof supports.

Comments:

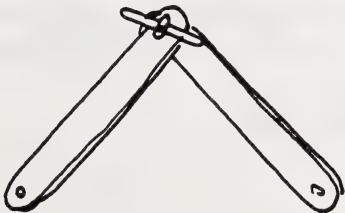
- If wooden stir sticks with holes near the ends are not available, the learning facilitator may be able to drill holes in ordinary ice cream sticks. Or, strips of stiff cardboard, approximately the same size as wooden stir sticks, with holes punched near the ends could be used instead. If making holes is not practical, then small nails or pins can be used to hold the stir sticks or stiff cardboard together.
- This activity is a construction activity. Check to see that the student has followed steps 1 to 10 and has understood the results of the observations made, especially for steps 3, 7, and 10. Check the answer for the optional step 11, if the student chose to do it.

Steps to Follow

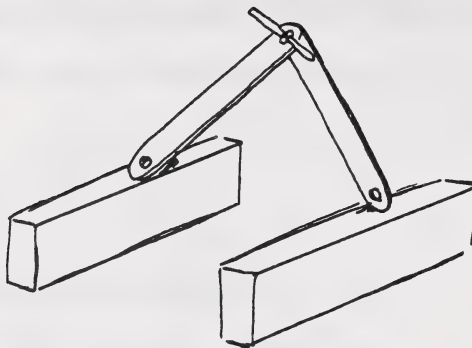
- Step 1: Place the wood blocks 8 cm apart to form walls for your prototype building.
- Step 2: Place a wooden stir stick across the walls to form a beam. Using tape, attach the ends of the beam to the walls.



- Step 3: Push down on the beam. Observe what happens to the walls.
- The downward force you apply to the beam results in a downward force on the walls. If the beam and walls are strong enough to support the downward force, the structure will stand.
- Step 4: Now place the wood blocks 16 cm apart. The stir stick beam is too short to reach from wall to wall.
- Step 5: Join two wooden stir sticks with a brass paper fastener.



Step 6: Use the joined stir sticks to form a sloped roof for the building. Tape the ends of the stir sticks to the walls.



A roof shaped like an inverted V allows you to span a distance greater than the length of the individual pieces. Another benefit of a sloped roof is its ability to shed rain and snow.

Step 7: Now push down on the top of the roof. Again, watch what happens to the walls.

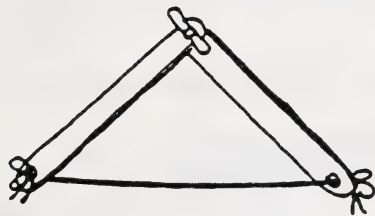
This time the downward force you apply to the sloping roof results in an outward force that tries to push the walls apart.



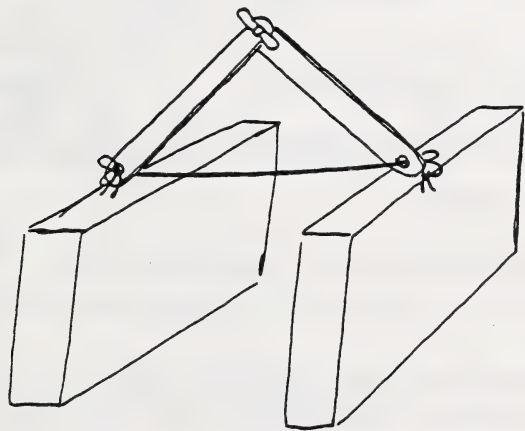
To solve this technical problem, you can use scientific knowledge about forces. You (or the weight of snow) pushed down on the roof. A pushing force is compression. The top of the roof, made of wooden stir sticks and a brass paper fastener, is strong enough to resist the compression.

The bottom of the roof is just the stir sticks resting on the wood blocks. The downward force on the roof seems to pull the walls apart. To keep them together, you (or something) must pull the bottom of the stir sticks together. A pulling force is tension. A string can resist very little compression, but it resists tension very well.

Step 8: Use a string to tie the bottom of the two wooden stir sticks together so that they are 16 cm apart. You have made a truss.



Step 9: Set the wood blocks 16 cm apart. Place the stir-stick truss on the walls. Tape the ends of the truss to the blocks.

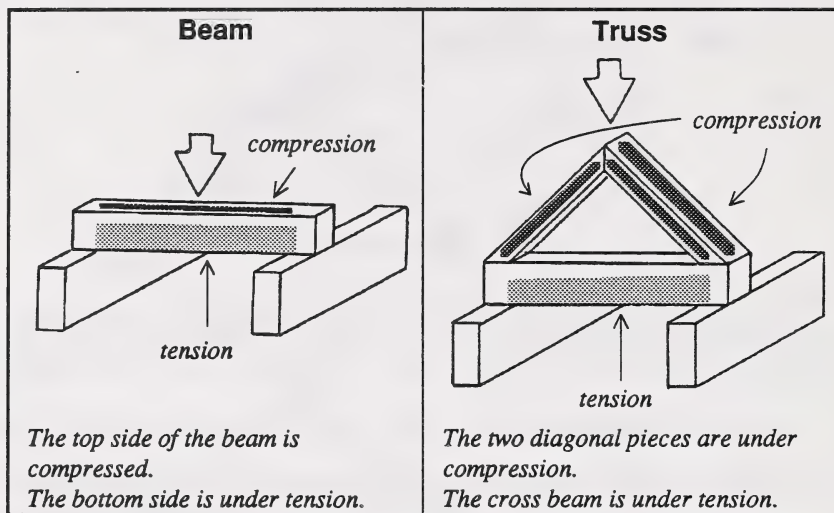


Step 10: Once again push down on the top of the roof, and again watch what happens to the walls.

This time the downward force you applied to the sloping roof does not push the walls apart. The string acts like the bottom of a beam resisting the tension (pulling apart).

Step 11: (Optional)

Compare a beam to a truss by indicating the areas of compression and tension on the following diagrams.



Section 3: Activity 6

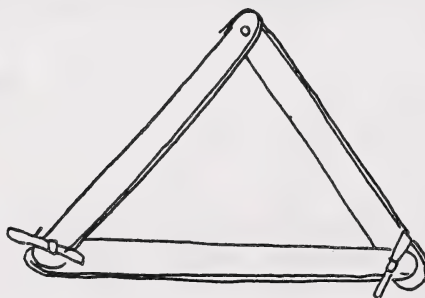
You will build a simple prototype of a wood frame building.

Comments:

Check to see that the student has understood the constructions for steps 1 to 4. Then check the answers to the questions.

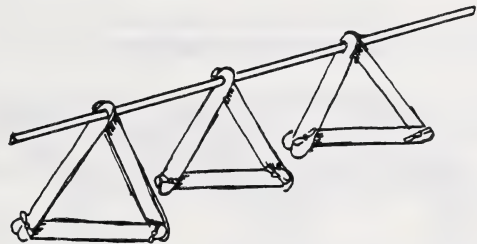
Steps to Follow

Step 1: Join three wooden stir sticks with two brass paper fasteners as shown.

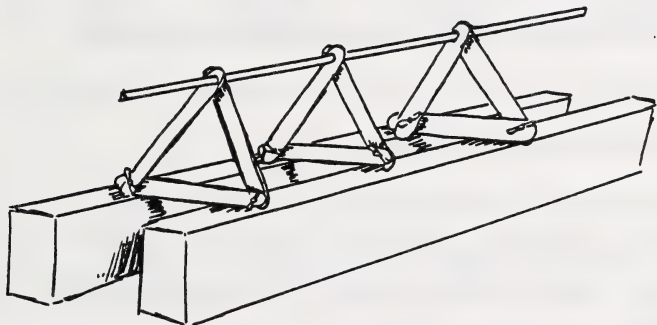


Step 2: Make two more sets of three wooden stir sticks, as in step 1.

Step 3: Insert the wood dowel into the holes at the ends of the stir sticks to make three trusses joined by the dowel.



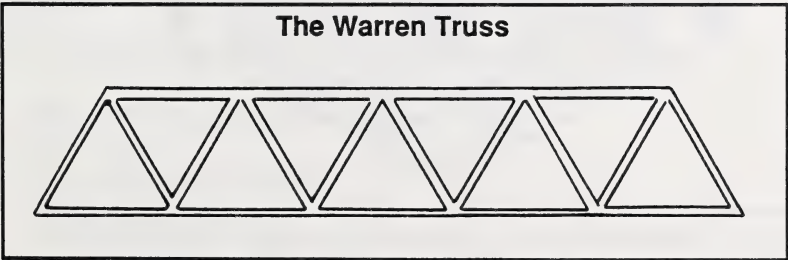
Step 4: Set the roof onto the wood blocks to make a prototype wood frame building.



Questions to Answer

See how triangles have been used in each of the following examples. Then answer the questions which follow.

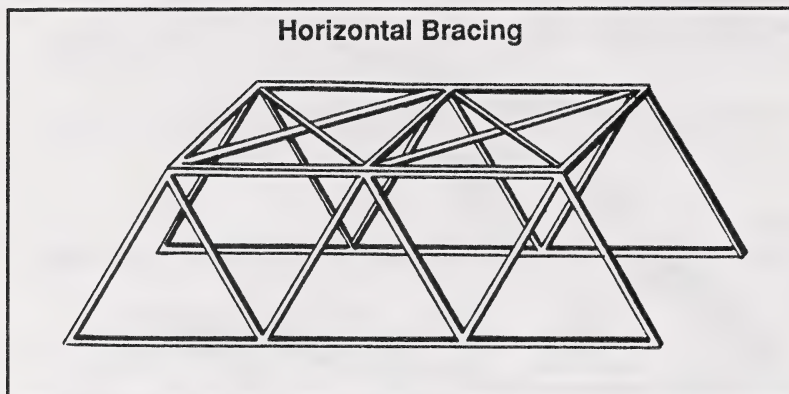
- 1. In 1848 James Warren patented a truss system that is still used in many structures today. Warren’s truss system is a simple combination of equilateral triangles.



Where do you expect that Warren trusses might be used?

Warren trusses are commonly used in bridges and to support roofs.

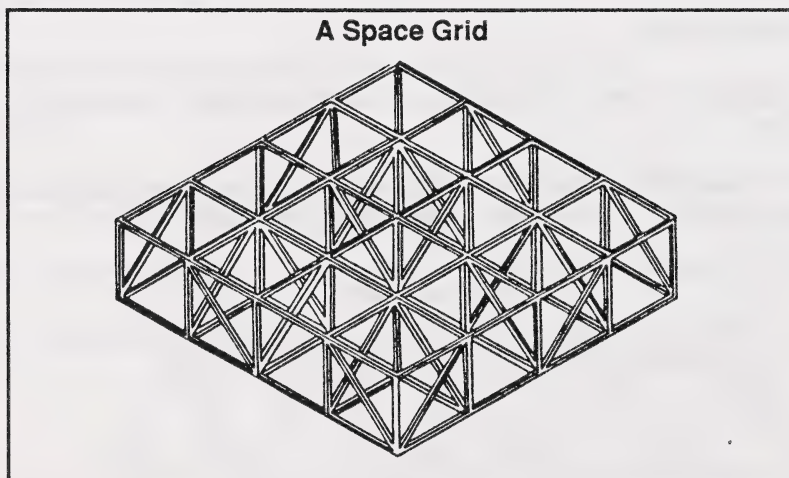
2. Horizontal bracing can be used over the top of Warren trusses.



Why would horizontal bracing be needed?

Without this bracing, the trusses might fall over. (The structure would not be stable.)

3. In large buildings, like airplane hangers and sports halls, trusses may be used in multiple directions. These are called space grids. Trusses of equal length and span are used in both directions.



Where would a space grid be useful? How could a space grid be used?

This is often used below roofs and under floors.

Section 3: Activity 7

Read pages 122 to 124 of *Science Directions 7* for information on making connections.

Both the bicycle and the human body include parts joined by mobile joints. Some of the joints in the rider's body have been shown in the diagram on page 124 of the textbook. Where are the other joints in the rider's body located? Can you see any joints in the bicycle?

1. Name one joint in the human body.

Answers will vary (e.g., elbow).

2. Compare a joint in the bicycle to the joint you named in question 1. What bicycle joint did you choose?

Answers will vary.

- a. In what ways is it similar?

Answers will vary (e.g., brake handles are similar). They bend in one direction.

- b. In what ways is it different?

With your elbow, your arm is not pushed back by a spring.

3. Name another joint in the human body.

hip joint

4. Compare another joint in the bicycle to the joint you named in question 3. What bicycle joint did you choose?

crankshaft

- a. In what ways is it similar?

They both swing around, at least a bit.

- b. In what ways is it different?

The hip joint does not go all the way around in a circle as does the crankshaft.

Section 3: Follow-up Activities

Extra Help

Comment:

The experiment that the student is to do in this Extra Help is based on the information given for Activity 2-9 on page 98 of *Science Directions 7*.

Steps to Follow

Step 1: Support the wooden block across the backs of two chairs or any other supports. The wooden block should be at least 50 cm above a surface.

Step 2: Tie one sample of thread securely to the wooden block.

Step 3: Attach the lower end of the thread to the bag or plastic container.

Step 4: Gradually add bags of sand or other small heavy objects, such as nails, until the thread breaks. Record the number of bags of sand that the thread will support without breaking.

Step 5: Repeat this test of tensile strength for the other samples of thread.

Observations

Type of Thread	Number of Bags Supported
<i>Answers will vary.</i>	

Questions to Answer

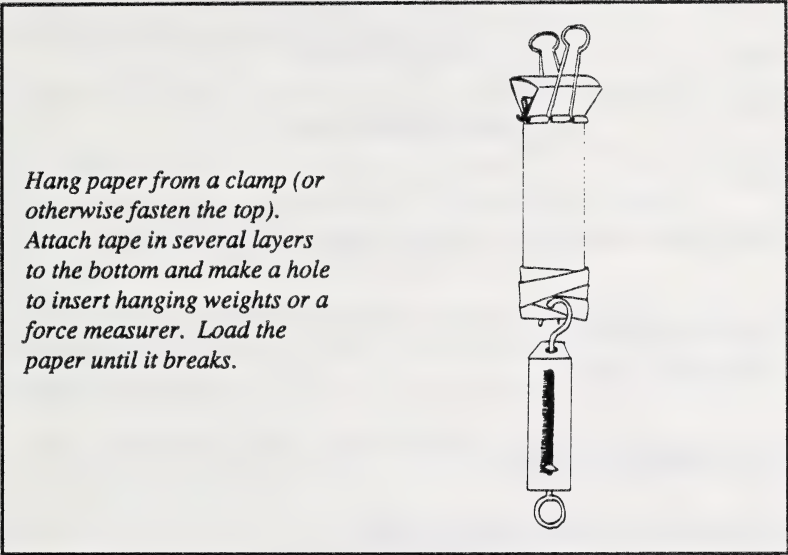
1. List the thread samples in order of their tensile strength, with the strongest at the top and the weakest at the bottom.

strongest thread

weakest thread

Answers should be consistent with the data in the observation table.

2. How could you test the tensile strength of different samples of paper, such as newspaper, paper towelling, grocery bag paper, and waxed paper? Use a diagram as part of your description.



3. Which would have a greater compressive strength, a pencil or a string?

a pencil

Explain how you know.

A string will resist a pull but it will not resist a push.

Enrichment

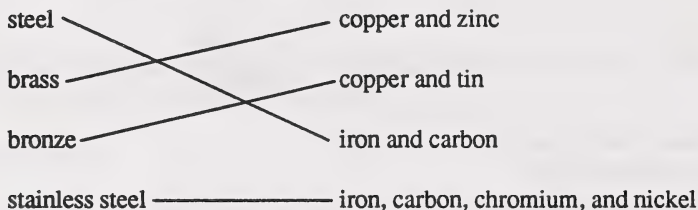
1. Bend a paper clip back and forth in the same spot until it breaks. How many times did you bend it?

Answers will vary. Some clips will break after being bent just a few times; others can be bent ten to twenty times.

2. Define metal fatigue.

It is the loss of strength of a material due to repeated stress, such as bending.

3. Use the information from the previous chart to identify each alloy. Draw lines to connect the name of the alloy with the metals from which it is made.

Alloys**Metal Combinations**

Note: The student should now complete the assignment for Section 3 in the Module 2 Assignment Booklet.

Section 4: Finding a Solution

By the end of this section students should be able to

- solve a practical problem in a planned way
- develop a prototype as a means to test their ideas
- use knowledge of compression and tension to help identify and evaluate alternative designs

Section 4: Activity 1

Comments:

- In this activity the student's task is to find a solution to a problem in a systematic way by using science information to help them. They will build a prototype bridge but with different specifications than those used in Section 1 to solve the problem. The specifications are stated in the Module Booklet.
- Check to see that the student has understood the problem and has kept notes while progressing through the problem-solving steps.
- Check to see that the prototype the student constructed meets the specifications listed.

Developing a Plan

1.
 - Where did you get ideas about the possible designs for your prototype?
 - How did you decide which design to build?
 - How did you choose which materials to use?

Developing a Plan

Answers will vary. As in the earlier section, students should be encouraged to use different sources for their ideas and to be critical thinkers when it comes to selecting materials.

Carrying Out the Plan

2.
 - Did you change your design once you started to build your prototype? Why?
 - How did you test your prototype?

Carrying Out the Plan

Answers will vary. Students should note changes to their design and comment on how they tested it. Diagrams as well as explanations might be given here.

Evaluating

3.
 - Were you successful in keeping your bridge as light as possible?
 - How did you decide when you had completed the task?

Evaluating

Answers will vary. Answers should indicate that the bridge was built according to design specifications, or that the student had tried a new idea that appeared worth testing.

Extension

4. Now that you have completed your prototype, include a diagram, or photograph, and a description of the prototype in the following space.

<p>Diagram of Prototype</p> <p><i>Diagrams will vary.</i></p>
--

Description:

Answers will vary. Drawings and descriptions should show plausible methods of design.

5. This part is optional.

Now build the lightest prototype bridge you can, but also do it for the lowest possible cost. Keep additional notes in the following chart about the cost of the materials for each of your alternatives and for the design you build.

Cost of Materials

Material	Cost	Number Used	Money Spent on This Material
pins	\$1 each	<i>Answers will vary.</i>	
straws	\$5 each		
thread	\$1 for 30 cm		
spaghetti	\$1 each		<i>Items in this column are the product of items in the previous two columns.</i>
wood dowel	\$10 each		
glue	\$1 for each mL		
Total Cost of Materials			

Section 4: Follow-up Activities

Extra Help

Why Be a Square When You Can Be a Triangle?

Comment:

The experiment that the student is to do in this Extra Help is based on information given in Activity 2-13 on page 112 of the textbook. This hands-on activity helps students learn how to achieve rigidity in structures.

Steps to Follow

Step 1: Join four strips of stiff cardboard with pins to make a square frame. Push the frame at point A. (See the textbook diagram.)

Without any reinforcement the square frame is not very rigid.

Step 2: Add one long strip of cardboard to your frame in a way that will make it more rigid. Test the frame by pushing at point A. (See the textbook diagram.)

One way the square frame may be made more rigid is by putting the long strip of paper diagonally from corner to corner, forming two equal-sized triangles. For example:



Step 3: Make another square frame. This time make it rigid by using four short strips of cardboard.

Answers may vary. One way might be to attach one end of each short strip of cardboard to each corner and then attaching the other ends of the short strips with a pin in the center of the frame, or another way might be to place one short strip of cardboard across each corner. For example:

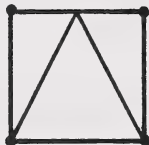


or



Step 4: Make a rectangular frame. Make it rigid by adding two strips of cardboard.

One way might be to place one strip from each of the bottom corners to join the top strip of the rectangle at the center forming three triangles. For example:



Making Rigid Sheets

Comment:

This Extra Help is based on information given in Activity 2-14 on pages 114 and 115 of the textbook.

1. Hold a sheet of paper by the bottom edge as shown in (a) on page 114 and try to make it stand upright. What happens to the sheet of paper?

If an indentation or bend is made in the paper, it will stand upright; otherwise, it will fall over.

2. Fold the sheet lengthways in half as shown in (b) on page 114. Now try to stand it upright.
 - a. How well does this work?

This design does not fall over. (It may if the paper is very thin relative to the overall size of the sheet.)

- b. What difference would it make if a different thickness of paper were used?

The thicker the paper, the less likely it is that the structure will fall over.

3.
 - a. Place the two blocks about 15 cm apart. Place a sheet of paper so that it makes a bridge between the two boxes as shown in (c) on page 115. Will this bridge support one of the 100 g test bags of sand?

Not likely – not unless it is very heavy paper.

- b. Make five folds in the sheet of paper to make it more rigid as shown in (d) on page 115. Will this bridge hold the test bags?

It should if the folded paper is placed between the blocks.

- c. Test the strength of your bridge by adding more test bags until the bridge starts to bend. How many test bags did it hold before it started to bend?

Answers will vary.

4. Can you make your bridge stronger by adding more folds? Try some different designs and test them by using the test bags as a load.

Describe what you tried and what the results were.

Answers will vary. Students should be encouraged to apply critical and creative thought.

Enrichment

A Case Study: Just an Ordinary Bridge

Comments:

This Enrichment is based on information given in Activity 2-16, on pages 119 to 121 of *Science Directions 7*.

1. What issues led people to decide that a new bridge was needed across the river?

The number of traffic jams and accidents led to the call for a new bridge. The traffic loads had increased greatly since the original bridge was built.

2. Once the decision was made to build a new bridge, state **at least three** questions the planners and engineers had to consider and solve before starting to build the bridge.

Students may state any three of the following five questions.

- *Which material takes longer to assemble and join together?*
- *Which material is more expensive?*
- *How much of each material would be needed for the bridge?*
- *Does one material have to be transported a longer distance than the other?*
- *Are the construction workers in the area more experienced using one material than the other?*

3. Give the ideas or plan they had for answering one of these questions.

Answers will vary.

4. What were some of the factors they had to evaluate in their building design?

Examples:

- *cost of material*
- *ease of assembly*
- *amount of material needed*
- *skills of available construction workers*
- *supply source for materials*

Note: The student should now complete the assignment for Section 4 in the Module 2 Assignment Booklet.

Section 5: More Decisions

By the end of Section 5 students should be able to

- recognize that the selection of materials and a design is based on many considerations
- identify differences in design to accommodate specialized needs or environmental conditions

Section 5: Activity 1

Comments:

In this activity students are to use a number of simple objects from a list of materials to design structures to carry out different tasks. They are to think about how they might use each object, how they might change its shape, or how they might combine it with other objects. They should plan their designs and change them if they don't work at first. Remind students not to worry about making mistakes as they can learn from mistakes. The world's greatest inventors have many more failures than successes. Encourage students to be willing to try to solve the tasks. There are several ways each task can be solved. Students' answers should show evidence of both creative and critical thought. The structures they design need not be elaborate, just effective.

Developing Your Designs

1. Fill in the following charts as you develop designs to solve each of the three tasks you have chosen.

First Task Chosen

Task Letter	Materials Used	Diagram of Design
	<i>Answers will vary. For example, if Task A is chosen, the materials and diagram should illustrate an effective means of transferring sand from one container to another.</i>	

Second Task Chosen

Task Letter	Materials Used	Diagram of Design
	<i>Answers will vary. For example, if Task B is chosen, the materials and diagram should illustrate an effective means of transferring water from one container to another.</i>	

Third Task Chosen

Task Letter	Materials Used	Diagram of Design
	<i>Answers will vary. For example, if Task C is chosen, the materials and diagram should illustrate an effective means of separating a ball of clay into three parts.</i>	

Comments:

Many designs and answers are possible for each of the tasks. Students will come up with some good, unique, ingenious ways to accomplish the tasks. Encourage original, creative designs. Following are only a few possible designs for Tasks A to E.

Task A: The designs may range from being simple to being very complex. Spoons could be made from pieces of cardboard or from modelling clay to do the job. Or, students may use the cardboard tube to build supporting structures to hold one container 15 cm above the other one, then the cardboard sheet could be used to make a sliding door to release sand from one container to another.

Task B: Some of the same ideas as used for Task A may apply here. One container may be raised and a straw poked through the bottom or side of the container and modelling clay could be used as a seal to prevent unwanted leaks. Water could then flow through the straw from one container to the other one.

Task C: Strips of cardboard or paper clips can be fastened across the cardboard or cup to form cutting edges to cut the modelling clay into three equal parts.

Task D: Students could pour sand into the tube and continuously prod the marble to keep it on top of the sand, or they use the straws and elastic bands to make a tweezer-like device to lift the marble, or they can attach some modelling clay to the end of a straw and lift the marble with modelling clay.

Task E: Modelling clay could be used to hold a straw upward against the ramp and the marble could be attached to the other end of the straw halfway up the ramp, or a piece of cardboard could be folded and attached to the center of the ramp to hold the marble, or an elastic band could be taped to the top edge of the ramp with the marble being held halfway up the ramp by the other end of the rubber band.

Evaluating Your Design

2. Once you have designed and built the structures for the tasks, evaluate **two** of your designs. Consider the following points:
- Did the structure accomplish the task?
 - Try to explain why it did or did not work.
 - Did you use any science knowledge to help you design the structure?
 - If *yes*, briefly describe the knowledge you used.
 - If *no*, what knowledge might have helped you?
 - Is the design creative? Briefly explain.
 - Include anything else that shows value for the structure.

Task Letter	Evaluation
	<i>Answers will vary. Answers should show evidence of a realistic critical appraisal of the work done.</i>

Task Letter	Evaluation
	<i>Answers will vary. Answers should show evidence of a realistic critical appraisal of the work done.</i>

3. Evaluating your design often leads to recommendations you could make about the design.

- Could improvements be made to your existing design?
- Do you need a completely different design?
- Did carrying out the task suggest a new problem you would like to solve?

Make recommendations for one of the tasks you evaluated.

Task Letter	Recommendations
	<p><i>Answers will vary. Answers should show evidence of both creative and critical thought.</i></p>

Section 5: Activity 2

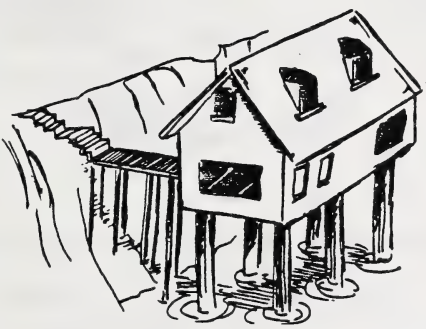

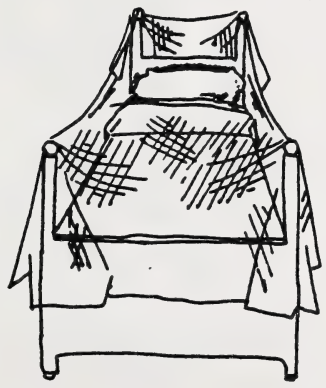

Note: Students are to do either Part A or Part B.

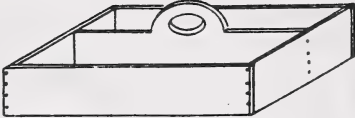
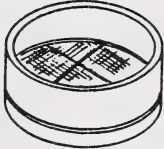
Parts A and B both involve looking at the functions of different designs.

Part A requires answering questions about diagrams. Part B requires viewing a videocassette called *Science of Architecture, Program 1: Part 1 Loads – Dead or Alive* (first ten minutes) and answering questions about diagrams.

Part A

1. Objects are designed for a purpose or function. Infer what the function of each of the following might be.


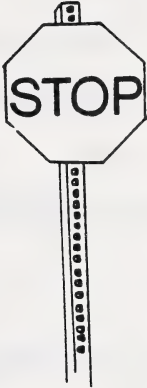
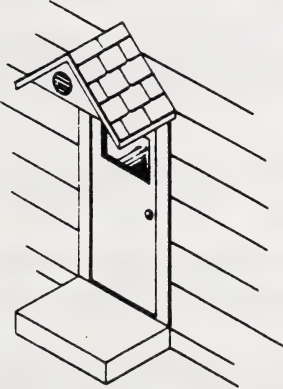

<div><p>House on Stilts</p><p><i>function: support for house built over water (or to keep the house above water)</i></p></div>	<div><p>Travel Mug</p><p><i>function: container for liquid; it will resist spilling when moved</i></p></div>
<div><p>Netting over Bed</p><p><i>function: protection from insects</i></p></div>	<div><p>Rubber Mallet</p><p><i>function: striking an object without damaging the object</i></p></div>

Box with Handle	Sieve
 <p data-bbox="262 635 682 663">function: <i>carrying tray for small objects</i></p>	 <p data-bbox="744 635 1181 690">function: <i>separation of fine material from course material</i></p>

Part B

View the videocassette called *Science of Architecture, Program 1: Part 1 Loads – Dead or Alive*. Watch from the beginning to just after the discussion about the locomotive (about ten minutes). The last sentence is “So the design of any form of structure depends not only on what it is doing or being used for, but also where it is.”

2. Study the following four common objects. Infer why they are designed as they are.

<div><p>Manhole Cover on a Road</p></div> <div><p><i>inference: The cover can be placed on at any angle and will not fall in.</i></p></div>	<div><p>Stop Sign</p></div> <div><p><i>inference: The height of the sign can be set to a standard height.</i></p></div>
<div><p>Roof over the Door of a House</p></div> <div><p><i>inference: The roof keeps one dry when entering or leaving the house.</i></p></div>	<div><p>Covered Vehicular Bridge</p></div> <div><p><i>inference: The roof keeps snow off the bridge.</i></p></div>

3. Steel and stainless steel are equally strong. Steel is less expensive and is attractive if painted. Stainless steel is expensive, has a surface that is easy to keep clean, and is very durable.

a. Which is used to make a truck? *steel (usually)*

Why? *The cost is lower.*

b. Which is used to make cutlery? *stainless steel*

Why? *It is easy to keep clean and is very durable.*

Section 5: Activity 3

Note: Students are to do either
Part A or Part B.

Part A: Low Gravity Problem

You will design structures to deal with the problems caused by living in near-zero gravity. You will find some ways to hold things in place, and move things in an environment where everything floats and where there are no ups and downs.

Part B: Closed System Problem

You will design structures to deal with the problems of living in a small, closed system. Air, water, and wastes must be recycled. Wastes and garbage cannot be flushed or taken away.

Write X in the appropriate space to indicate which problem you choose to work on. Then answer the questions which follow. The same set of questions apply whether you choose Part A or Part B.

_____ **Part A: Low Gravity Problem**

_____ **Part B: Closed System Problem**

1. Under the heading *Developing a Plan* list three things you must consider, taking into account the design differences between Earth and your spacecraft (differences such as water will float and garbage cannot be taken away).
2. Under the heading *Creating a Design* describe how you would design the interior of your spacecraft to overcome the three things you listed. Remember to consider:
 - human needs
 - environmental factors
 - cost considerations (don't have excess mass)

Use either point form or paragraphs and include diagrams if you wish.

Developing a Plan

Answers should show evidence of critical thought regarding conditions that are different on Earth and in space.

Considerations might include:

- *differences which result from the absence of gravitational force or from low gravitational forces*
- *differences which result from the need to carry all materials required within the spacecraft, including air and water*
- *differences which result from the need to work in confined spaces*

Creating a Design

Answers should show evidence of consideration of each of the three factors mentioned in the instructions; i.e.:

- *human needs*
- *environmental factors*
- *cost considerations*

Answers may focus on the overall design of the spacecraft or on particular portions of the spacecraft.

Section 5: Follow-up Activities

Extra Help

1. Imagine that you were designing a canoe and had to decide if you were going to use aluminum or wood.
 - a. What is one property of wood and aluminum you would want to consider?

Answers will vary; e.g., strength, weight, cost, durability.

b. Why?

Example answer: Strength is an important consideration as the canoe may occasionally come up against rocks.

c. What is one other consideration that would be important?

example answer: weight

d. Why?

Weight is an important consideration because the canoe may have to be carried for long distances.

2. In the following chart write one property of each of the materials listed. In the third column write a function that this material can be used for. The first one has been done as an example.

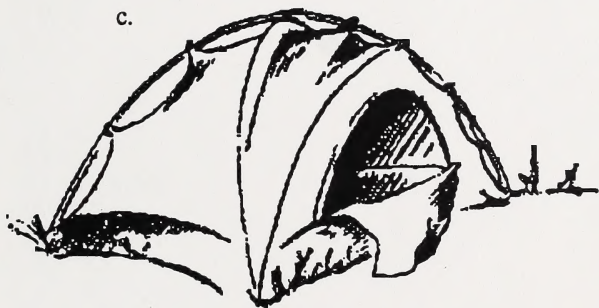
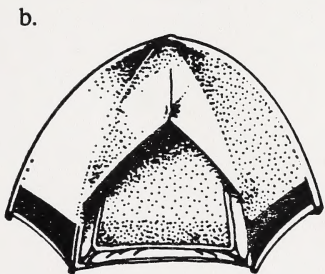
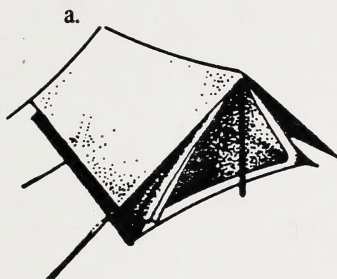
The following answers in the chart are examples.

Material	Property	Function
glass	transparent	windows
rubber	<i>flexible</i>	<i>seal around window</i>
wood	<i>strong but light</i>	<i>chopsticks</i>
paper	<i>very light</i>	<i>kites</i>
metal	<i>strength</i>	<i>car frame</i>
cloth	<i>flexibility</i>	<i>covering material</i>

Enrichment

You have to choose a new tent for two people. Assume that the cost of the three tents shown here is the same for each. You have three major concerns.

- The tent should be easy to transport in a canoe.
- You must be able to put the tent up quickly because there are many mosquitoes in the area.
- The tent must have plenty of space for two in case of rain.



1. Which design would you choose: a, b, or c? *Design a, b, or c are all acceptable.*
2. Why would you choose this design over the others?

Answers should indicate evidence of critical thought with reference to the criteria listed.

- Note:**
1. The student should now complete the assignment for Section 5 in the Module 2 Assignment Booklet.
 2. Check to see that all assignments have been completed and that all written work is done neatly in blue or black ink. Diagrams may be left in pencil.
 3. The completed Assignment Booklet should now be submitted to the Alberta Distance Learning Centre for correction. The student can proceed with the next module while waiting for the return of the Assignment Booklet.



L.R.D.C.
Producer

Science 7
St. Support Guide
Module 2

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